THE INSTITUTION OF PRODUCTION ENGINEERS

AUTOMATIC SCREW MACHINES

Paper presented to the Institution, Sydney, New South Wales Section, by W. F. Dawson, M.I.P.E.,

This paper describes single-spindle and multi-spindle automatic screw machines from the users' point of view.

The amazing speed and versatility of the single-spindle machines is shown. Practical hints on cam layout and manufacture are given, special attention being paid to the blending of multi-feeds on a single lobe. Problems of dwell and approach time are also discussed. The advantages of eliminating unnecessary indexing of the turret are made clear and a remedy suggested. The use of form tools where possible is recommended.

The section on multi-spindle machines commences with a clear enunciation of the advantages of the eight- and six-spindle machines over the four-spindle automatics. On multi-spindle machines, the time of production is shortened to that of the longest single operation plus index time.

The discussion which follows the paper includes such subjects as minimum batch numbers, frequency of tool regrinds and the value of tipped tools, especially for casein, bakelite and ebonite products.

Type 1. Single Spindle Machine with Fixed Tools and Movable Stock.

THIS machine is of Swiss origin and employs the " Bush Turning " method, the tools remaining stationary while the work which is supported in a bush during the process is fed forward against the tools. This type of automatic is very suitable for work which is long compared with its diameter, since the work is supported very close to the tools. In threading long slender work with the die following close behind the turning tool on the over-taking principle, no difficulty is experienced in keeping the thread concentric with the diameter turned.

This " Bush Support " method is very suitable for the making of pivot pins and double pointed cone spindles as used in clock and instrument manufacture. An essential of the " Bush Turning " method is that the size of the stock must be correct to close limits. Any variation in the size of the stock is conveyed to the finished diameter, and oversize stock must be graded and the bush adjusted before using. With the advent of the new hard materials, bush wear is not very serious and in recent design the bush rotates with the stock and is made adjustable similar to a spring collet. These machines run at very high spindle speeds, approximately 7,500 revs. per minute. The feeds are fine and, for work not requiring a great number of operations, the machines are capable of producing

a very excellent quality product. They are not expensive, do not occupy much floor space, and the time for changing from one product to another is very low. The changing from one turning length to another does not always require the making of new cams or even the changing of cams, as the length of cut and feed is determined by the adjustment of levers and the moving of a belt on a cone pulley to give the required feed without any loss of efficiency. Some of the later type of bush turning automatics using slide tools of the " swing in " type allowing a short and quick approach have been made more universal by the introduction of various attachments.

Type 2. Single-spindle Machine, Turret Type.

These machines are gems from the designer's brain, being most universal and capable of handling a great variety of intricate, accurate, and difficult work. They are designed to produce work requiring a large number of operations and when used in conjunction with the many attachments which are furnished they are indeed wonderful to watch in operation. I remember on one occasion showing some civil engineers these machines in action and warned them about the danger of oil being thrown up. They became quite interested, and when I noticed one of them step further away, I asked him if he had been splashed. His reply was cryptic. " No, I'm not frightened of the oil, I am moving away before I get my pockets picked." I think that remark humorously indicates how universal these machines are.

Most of the attachments for tapping, back countersinking, back end threading, slotting, index cross drilling, etc., are in use at the same time as the major piece is being made from the bar. Consequently, no further time is taken and the piece is finished when dropped at the time taken for the major operation. On brass work it is not unusual for work requiring turning, threading, and slotting to be completely finished in .8 seconds each. So rapid are these machines that hand feeding of the bars would necessitate constant attendance. To overcome this necessity, mechanically and electrically controlled magazines for feeding the bars are listed as stock items.

Cams.

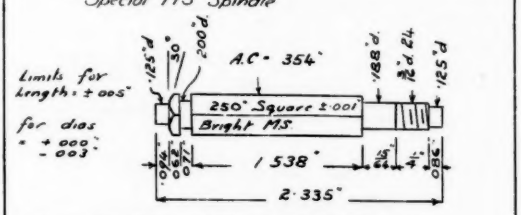
These machines, unlike the earlier type discussed, are not supplied with cams as standard equipment but require cams to suit each individual product. Generally three cams are needed, one lead cam, and two cross slide cams, one for transporting the work and the other for feeding the work in the secondary operation. For ordinary screw head slotting standard, transporting and feeding cams will cover almost any type of screw and are supplied with the

machine. One great advantage of this type of machine is that you can do your operations in any sequence you desire. If the part to be made is long in proportion to its diameter you can feed out the stock part way and operate close to the collet. Then feed out again and finish the operation. In fact you can feed out as often as desired before cutting off.

The cams, if made from mild steel and case hardened, will produce millions of parts and will, in fact, outlast the machine. For short runs of 1,000 to 50,000 pieces, close grained cast iron cams are quite suitable. These cams are of the disc type, machined all over.

Cam Layout Chart

Special MS Spindle



Cams N°130 = 3 Cams N°0 B&S Auto.

Mach.	Cut Down	Operations	Rise	Feed	Revs 810	Revs 1800	Hund Com	Tools
N°0	Top	Feed Stock 1st				22	4	Stop.
		I T				20	4	
	Top	Turn Body	·490	·0028		102	20	Box Tool
		Dwell				5	1	
		I T CSS				22	4	
	Top	Thread	·375"		9	20	4	3/4" Whd Chasers
		Dwell				5	1	5/16 Concentric head
		I T				22	4	
	1"	Feed Stock 2nd CSS				22	4	Stop
	1"	I T				20	4	
		Steady from T				165	33	Ball Race Steady
		Form Rough FS	·100	·0015		67	14	Circular from Tool
		Form Finish FS	·040	·0005		80	16	H.S
		Dwell				6	1	
		Cut off & form 125"d FS	·120	·0015		80	16	Circular from Tool H.S
		Dwell				5	1	
		Seconds = 17				510	100	

Fig. 1.

They are approximately 7 in. diameter by $\frac{3}{8}$ in. thick, with one side divided off into one hundred parts for spacing the operations required. In designing a set of cams the most difficult matter to decide is just how to make the piece, and how to arrange the sequence

Lead Cam N°130

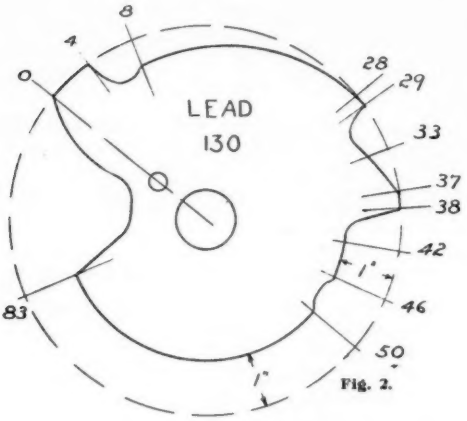
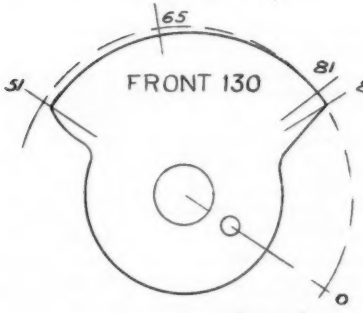


Fig. 2.

Cross Slide Cams N°130



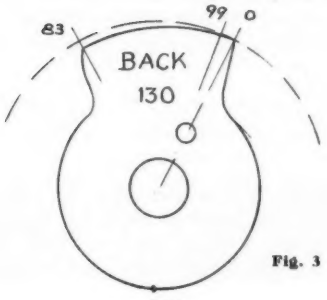


Fig. 3

of operations. Shall the component be box-tooled or formed, and which operation (there may be eight or a dozen) should be done first ? In deciding just how to make the piece experience is the best guide, and many examples of excellent machine shop practice are to be found in text books and periodicals published on this subject. I shall submit several examples from actual practice which may be helpful.

After deciding the sequence of operations the next thing is to make a layout chart for tools and cams, Fig. 1 (for the beginner I

CAM CUTTING CALCULATIONS

Lead. of Cam = $\frac{\text{Rise} \times 100}{\text{No. of Hundredths}}$ =

$\frac{\cdot 490 \times 100}{20} = \frac{49}{20} = 2 \cdot 45''$

Gear machine for. 3" Lead. Then

$\frac{2 \cdot 45}{3}$ = The Sine of The Angle To Set The Dividing Head.

$= \cdot 815$ = Sine of. $54^\circ 35'$

Then. $54^\circ 35'$ is the Angle for. The Dividing Head & The Vertical Head is Set To The Complement = $35^\circ 25'$

Fig. 4.

would suggest a preliminary layout chart) selecting speeds and feeds as shown on the tables. When the final layout chart is finished, the cam blanks are marked out in accordance with the chart, and the usual method is to mark in the shape of the cam outline with an indelible pencil. Fig. 2 and 3. Then drill a series of $\frac{1}{4}$ in. diameter holes around the outline, rough grind the shape on an emery wheel and finally mill the exact rises of the cam on a universal milling machine. Fig. 4. Where large quantities of cams are required special cam cutting machines are used. These operate on the pantagraph principle in which a tracer follows an accurate drawing of the cam, and burns out the shape ready for finish milling either on another special cam cutting machine or in a universal milling machine.

On intricate work of many operations where tools are working in conjunction with other tools, where swing tools and recessing

tools are operated from the cross slide cams, it is best before marking out the cam blanks to make accurate drawings or templates. Then superimpose one cam on another to make sure of clearances, and to see that interference and proper timing are allowed for. Cam lever templates greatly facilitate the work when deciding clearances and the accurate timing of the lead and cross slide cams. Cam lever templates and templates for the rise and fall of the cam lobes are stock items and are generally made from celluloid to facilitate operation on the drawing board. It is sometimes necessary to have varying feeds on the one lobe. For instance, when forming slender work to a small diameter the first rise on the form may be .001 in. per revolution of the spindle, then as the piece becomes weaker the feed can be decreased .0005 in. per revolution. Also, when drilling deep holes it is invariably necessary to reduce the feed as the drill feeds further into the work. When cutting off it is excellent practice to reduce the feed of the cut-off tool just before the piece is severed from the bar to avoid any pip being left by the cut-off tool, the removal of which may entail a secondary operation. These multi-feeds on the one lobe do not entail any great difficulty and are a refinement with many advantages.

When milling a lobe having more than one feed, in most cases the fine feed part should be milled first, round the full length of the lobe, then it is an easy matter to blend the coarse feed into the fine feed at the desired point. With a cut-off cam in which the feed is reduced just before the piece is severed from the bar, it is necessary to again increase the feed just after the piece is dropped, to reduce the time necessary to cut off the pip left on the end of the bar and also to point the end of the bar to the shape required. Thus we have a cam lobe with three different feeds. In this case the second coarse feed which follows the fine feed portion, must be milled last, and no difficulty will be experienced in blending this lobe into the fine feed portion.

These multi-feed lobes are excellent examples of machine shop practice and indicate the wonderful control the designer of cams has over this type of automatic. It is necessary to allow one or two hundredths of an inch dwell at the end of the form cam-rise or on the lead cam which operates the turret tools. Box tool lobes require a slight dwell to enable the tool to finish off without burrs being left. Also, when using self-opening die-heads for threading, one to three hundredths dwell may be necessary, to allow the revolutions of the spindle to draw open the die-head. The amount of dwell taken depends upon the time required to make the piece in question. Three second work would require a longer dwell than sixty second work, and fine threads would require a longer dwell than coarse threads to allow the die to open without shock.

When designing threading lobes for opening die-head use, it is imperative that the rise of the cam and the revolutions of the work spindle are in the correct ratio. If the rise is too fast the thread will be too thin, and if the rise is too slow the start may be weak and the die-head will open before the necessary length of thread is cut. Thread lobes for opening die heads can with advantage be from 2 to 3% slower than the actual calculated rise. Tap and spring die lobes can be from 5 to 10% slower, depending on the pitch of thread required. When calculating the threading lobe rise, it is necessary to allow what we call approach time. For instance if the thread required is $\frac{1}{2}$ in. long, the rise on the cam would be approximately $\frac{5}{8}$ in. to $^{11}/_{16}$ in. This approach time

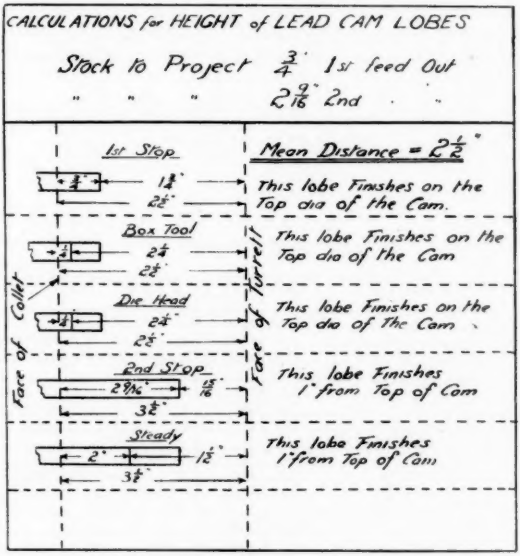

CALCULATIONS for HEIGHT of LEAD CAM LOBES
Stock to Project 3/4" 1st feed Out
" " " 2 9/16" 2nd
1st Stop
Mean Distance = 2 1/2"
This lobe Finishes on the Top dia of the Cam.
Box Tool
This lobe Finishes on the Top dia of the Cam
Face of Collet
Face of Turret
Die Head
This lobe Finishes on the Top dia of the Cam
2nd Stop
This lobe Finishes 1" from Top of Cam
Steady
This lobe Finishes 1" from Top of Cam

Fig. 5.

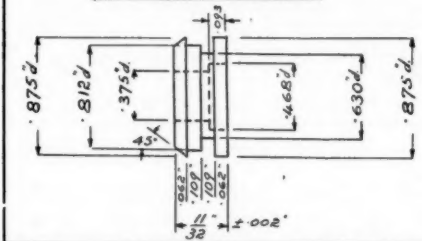
allows the die to settle down to the correct rate of travel after indexing the turret, and also allows the spindle, which has probably just changed speed for the threading operation, to settle down to the correct revolutions. Approach time is also necessary on all form and cut-off tools, box-tools, etc. In these instances an approach time of .003 in. to 005 in. would be sufficient to prevent the tools hooking into the work.

In threading with spring dies and tapping brass it is not always

necessary to change speed. In many instances this operation can be performed at the maximum speed of the machine. In this case the take-off lobe for the tap or die would be the same rise as the take-on lobe. When working on steel it is usual to tap or thread at a lower surface speed. After changing speed for tapping it is usual to tap out on the fast speed and the take-out lobe must be calculated on this fast speed. Generally speaking the slow speed is 50% slower than the fast speed, and if the lobe for tapping-in occupies ten hundredths of the cam surface, the withdrawal lobe

Cam layout Chart. 3 Pieces Per Rev of Cam

MS SPECIAL WASHER



Cams N° 260 - 3 Cams - 2G BRS Auto

Mach	Cut Dwg	Operations	Rise	Feed	Revs 796	Revs Cam	Hand Cam	Tools.
2G		Form F.S. I.T.	·125	·0015		111	21	HS Dovetail form tool F.S.
		Drill Tap hole	·5	·0065		111	21	Spec. H.S Combination drill
		Cut off B.S.	·23	·0015		160	30⅝	HS Blade tool B.S.
		Feed Stock to Stop				16	3	Stop
		Form F.S. I.T.	·125	·0015		111	21	
		Drill Tap hole	·5	·0065		111	21	Special H.S. Comb' drill
		Cut off B.S.	·23	·0015		160	30⅝	
		Feed Stock to Stop				16	3	Stop
		Form F.S I.T.	·125	·0015		111	21	
		Drill Tap hole	·5	·0065		111	21	Special H.S. Comb' drill
		Cut-off B.S.	·23	·0015		160	30⅝	
		Feed Stock to Stop				16	3	Stop
						528		
			40 Sec			530	100	

40/3 = 13·33 Seconds Each
Gross Per hour = 270 - 10%
Net " " = 243

Fig. 6.

would occupy five hundredths of the cam surface, as the speed for withdrawal is twice as fast as the speed for tapping in. The cam speed, of course, at all times is constant and is controlled by the change gears which govern the production rate.

In designing the lead cam for work requiring the use of box-tools, die-heads, knurl tools, etc., it is important that the cam lobes are designed to finish at the correct height, or trouble may be caused in two ways. Either the tools will not go back far enough into the turret, or when drawn out to their maximum allowable length, may not reach to the required position on the work. Particular reference is directed to Fig. 5. It is necessary to make a chart of this description before machining the cams. The first requirement is the least distance obtainable between the collet face and the turret face, and what length of independant adjustment the turret slide or saddle has.

One chart refers to a machine whose least distance between the collet face and turret face is $2\frac{1}{2}$ in., and as the turret has an independant adjustment of 1 in., I generally work on the mean distance, that is 3 in., and then have $\frac{1}{2}$ in. adjustment either forward or backward as required. The height of the cam lobes determines the

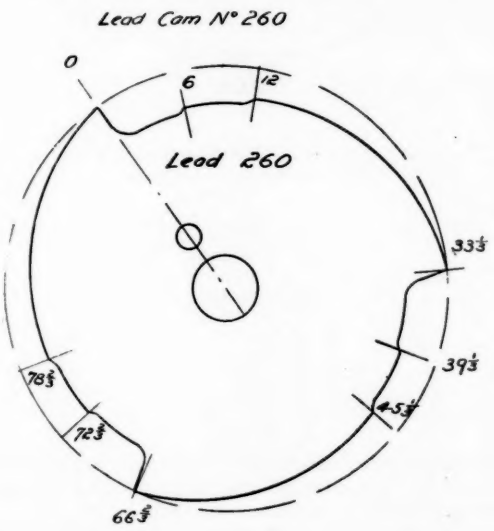


Fig. 7.

finishing position of the turret tools on the piece exactly the same as the stops so well known on capstan lathes. Cams should be designed to use as much of the cam surface as possible.

When practical, it is good practice to make three pieces per revolution of the cam (see Fig. 6). This chart shows three pieces

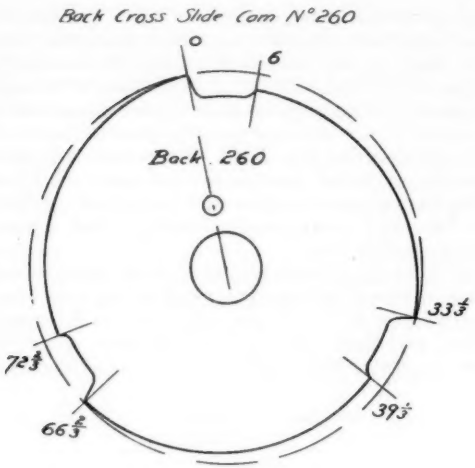

Back Cross Slide Cam N°260
0
6
Back 260
33⅓
72⅔
66⅔
39⅓

Fig. 8.

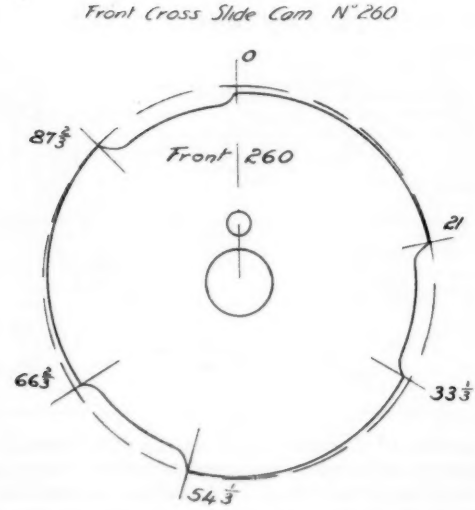

Front Cross Slide Cam N°260
0
87⅔
Front 260
21
66⅔
33⅓
54⅓

Fig. 9.

being made per revolution of the cam blank. This entails three sets of tools in the turret but the saving in indexing time of the turret and the quiet working of the machine is apparent. For if the cam was laid out for one piece per revolution of the cam-shaft, at a production rate of twelve seconds the turret has to index round very quickly to be ready for the next piece. By using three lobes and three sets of tools the speed of the camshaft would be reduced to thirty seconds and the production rate would be 30/3, i.e. ten seconds each piece, a saving in production time of approximately 17% and a great saving in machine wear and tear. Cams designed on this principle have three sets of lobes on each blank, Figs. 7, 8,

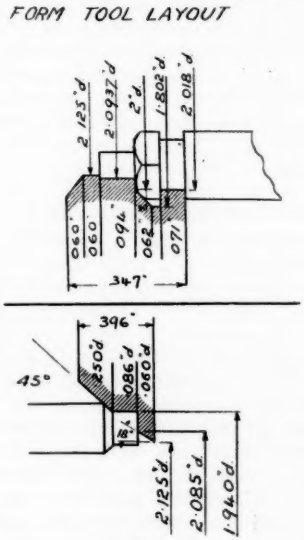


Fig. 10.

and 9, but whereas the turret is fitted with three sets of tools which are adjustable, the cross slide cams operate only one tool each with the three lobes, and in this case the radius of the three lobes on the cross slide cams must start and finish on the same pitch circle, otherwise you will get various form diameters for the three pieces. In preparing the work lay-out chart, select speeds and feeds from tables as shown. Time for feeding stock, indexing the turret, changing the spindle speed, and reversing the spindle are given in the makers' catalogue or operators' handbook accompanying the machine in question.

Form Tools.

Where possible, I always prefer to use form tools to envelope the whole piece to be made in preference to using two or three box tools or the one box tool with two or three blades. The form tool once made correctly is like passing a snap gauge over the work, Fig. 10 and with shoulder pins with two or three diameters and lengths, the form tool method will generally give a much better product and save considerable time in the inspection department. Where the form is long in comparison to its diameter it is advisable to form one section of its length with the form tool in the front slide and the other section with the cut-off tool in the back slide. Circular form tools have a long working life and are particularly suited for work with chamfers and radii, but when deep forming is required with square shoulders the slab form tool is to be preferred because it is much easier to allow clearances on square shoulders with this type of tool than with the circular type. Circular form tools are turned in the lathe, and the slab form tool is generally made in the shaping machine. In each instance the tools should be ground all over after hardening.

Type 3. Multiple Spindle Automatics.

Four spindles automatics were the pioneers of the multiple spindle type. The tendency now is to design six-spindle and eight-spindle machines. With the four-spindle machines the indexing between operations takes place through an arc of 90 degrees. Considerable effort is required to index through 90 degrees four steel bars of say 2½ in. hex. by 12 ft. long, especially when working at approximately 200 ft. per minute for turning, etc. Advantages with the six- and eight-spindle machines are that the indexing takes place through 60 and 45 degrees respectively, consequently the absence of strain and noise and the reduction of wear and tear are apparent. With six and eight spindles, more stations are available for tools, and with these machines stock can be fed out in two or three positions. Also, threading and tapping positions are available in three and four stations, whereas with the four-spindle machines there is usually only one position for threading and at times this is required for tapping. It is thus obvious that the six- and eight-spindle types are capable of producing finished work requiring a greater number of operations than that which can be manufactured on the four-spindle type.

Multi-spindle machines are capable of producing long work pieces Turning operations of 8 in. and 9 in. in length are quite usual. Also, heavy forming of great width is well within the capacity of these machines. After heavy forming, stations are available for shaving tools to insure sizes to close limits, also as a guarantee of good finish. From the point of view of metal removed and parts made per hour,

this type of machine is in a class by itself, and production is of a very high order. Considering the four-spindle machine set up to produce three pieces per index of the machine, production of 2,000 pieces per hour is quite common, with a proportionately increased production for six and eight spindles. Attachments for secondary operations such as rolled threading, cross hole drilling, slab milling, and accelerated drilling attachments are stock items.

Cams.

The cams for multiple spindle automatics are of the segmental ring type, usually made in cast iron and secured to drums mounted on the cam-shafts. These cams are very simple and are regarded as stock items by the manufacturers of the automatic. Generally, all cams of the same type are the same length—e.g., lead cams would all be the same segmental length. Also all form and cut-off cams would be of the same segmental length with varying rises. Lead cams may rise in $\frac{1}{4}$ ins. and the form and cut-off cams in $\frac{1}{16}$ ins. Unlike the single spindle turret automatics, the cam-shaft does not run at a constant speed. There are two speeds to the cam-shaft, one called the working speed and the other the idling speed or idle motion speed. The working speed of the cam-shaft is controlled through a comprehensive gear box similar to a quick change gear box on a lathe. With this gear box the feeds are selected for the cams to suit the work in hand.

Calculating Production.

Production on multiple spindle automatics is controlled by the time taken for the longest single operation. The ideal condition is reached when all tools working at correct feeds start and finish together. If the longest single operation requires 200 revolutions and the other operations require 100 revolutions each, then every endeavour must be made to try still further to reduce this 200 revolution operation to a time as close as possible to that of the 100 revolution operation. Speeds are selected as indicated previously for single-spindle machines, but feeds can be somewhat heavier as these machines are more massively built. Having selected speeds and feeds, production is given by the following formula :—

$$\frac{\text{Revs. for longest operation} \times 60 \text{ secs.}}{\text{Revs. of work spindle per min.}} \text{ Plus index time.}$$

= seconds to make one piece.

In conclusion, I wish to thank Mr. Steer and Mr. Blunt for their assistance in supplying their latest catalogues, and also to thank Mr. Curtis for his help with the epidiascope.

Discussion.

MR. J. FINLAY: Has Mr. Dawson arrived at the number of components when you switch over from a hand to an automatic machine? When in London I made inquiries from members in the London Section of our Institution and my information was to the effect that when the components reached approximately 1,000, they thought seriously of putting the work on an automatic machine. Can Mr. Dawson give us some idea of the life of an automatic machine?

MR. DAWSON: It is difficult to decide just when to change over to an automatic screw machine. It depends on the type of work. When I have over 500, if I have the cams to cover the job, I put it on the automatic. On the automatic, you have a better chance of turning out an accurate job than with the turret. With the turret, I find that the operator's sense of feel varies from one day to another. Generally it is not worth while developing a set of cams for a job unless the number of pieces required is at least 2,000. With anything over that amount, I would change over to the automatic. Where the job is difficult and needs a lot of forming, I would change over at approximately 1,000 pieces.

In respect to the life of an automatic machine, it can be run efficiently for at least twenty years; that is, if the design has not changed in the meantime to such a degree as to make the machine obsolete. We have had machines running for many years; but from time to time we strip them down and rebuild them from the ground up, reconditioning every piece. Sometimes we alter them in accordance with a later design. For example, on one machine we could only index one at a time. It has been altered, and now we can index two at a time. We embody the latest ideas on our automatics, when we recondition them.

MR. GRIEVES: What type of labour would you use on a single spindle machine, and how many machines of the small type can one man look after?

MR. DAWSON: The operation of setting up can be done by a lad—i.e., preparatory setting up; but it would take from twenty minutes to half an hour to adjust. It is not unusual for one man to be looking after four or five machines, but it depends on the speed at which the machines are running. It is easier to attend to a machine running on a thirty second production than one on three seconds. If changing over every two or three days, it requires approximately one man and a boy to control four machines. Four spindle machines are heavier and take a lot of handling. I think one setter can look after as

many as six single spindle machines, but he could only handle three, or four, four spindle machines, that is, if the work is constantly changing ; but, when set up for a month, one setter could look after as many as seven or eight machines.

MR. BADROCK : Have you seen the bar magazine feed apparatus in operation ?

MR. DAWSON : No, I have not. The bar magazine feeding apparatus has been added since we purchased our machines. The only knowledge I have is from what I have read.

MR. BADROCK : Unless you ran the gauge over the bars prior to putting them in the bar magazine, there might be trouble.

MR. DAWSON : I would not think so, for any machine other than the machine using the bush turning method.

MR. BADROCK : They will not work on varying diameters.

MR. DAWSON : Oh, yes ; within standard limits on mild steel of plus .000 in. and minus .002 in. and on brass of plus or minus .002 in. Rods within these limits should not give any trouble except with the bush turning method when all rods should be graded unless the bush is adjustable.

A VISITOR : With regard to threads, you did not mention the button die. Have you had any experience ?

MR. DAWSON : We use button dies and spring dies extensively in our business, but we prefer the spring or acorn die. It is a standard tool, and I like it. The advantage with spring acorn dies is that you can grind them easily. They give very little trouble especially when working on brass. I personally like the acorn die for brass because it has not so many loose parts as the opening die, but I prefer the opening die for steel.

MR. MANNING : On the Brown & Sharpe O.G. machine they have a space on the index plate for putting in runners, and another set of four holes. You generally index with two plates. What are the spare holes in the index plate for ?

MR. DAWSON : I do not know what the extra holes are for. I only know you can arrange to index one turret position at a time or two at a time. Just what the extra holes are for I cannot say, but will be pleased to give your question further consideration.

A VISITOR : How do they thread-grind a No. 13 BA button die ?

MR. DAWSON : I do not know how they would thread-grind so small a die. I think they might mean lapping the thread or grinding the throat of the die.

MR. MANNING : Have you a liking for any special steel for cutting brass ?

MR. DAWSON : No special liking. We use tungsten carbide tipped tools if the order warrants them. Mostly we use high grade oil or air hardening steels and on intricate formed work we would use steel hardening at a low temperature to preserve the shape and

finish on the form tool. It is wonderful how some of the special high-grade carbon steels retain their cutting edges, and tools made from these steels would run ten to twenty hours between grinds on free cutting brass.

A VISITOR: What would you call a reasonable time for regrinding the tools?

MR. DAWSON: If you mean to sharpen all the tools in a set then the time would vary from, say, five to twenty minutes. If you mean running time between grinds, perhaps from four to sixteen hours would be an approximate time. Some tools on brass run forty hours between grinds. Once a set up is well away we grind by the clock, say, every six or eight hours. It is excellent practice to grind early rather than wait till the product shows poor finish. If you are forming metal with a hard skin you may have a lot of regrinds, and it is good practice to rough off with a knee tool or box tool so as to preserve the form tool.

A VISITOR: Do you always find it good practice to use tools stipulated in the book?

MR. DAWSON: Yes.

A VISITOR: Do you use tungsten carbide tools on the automatic?

MR. DAWSON: Yes, definitely, particularly on casein products. I had in mind to bring along a set of special cams for a single spindle machine using tipped tools on casein. It is good practice if you are making a sufficient quantity to warrant the expense, to use tips or diamond tools on ebonite and bakelite or casein products. We did a very nice job in casein on the automatic with tungsten carbide tipped tools. It was a knob, something like the handle of a shaving brush with a fancy form $1\frac{1}{2}$ in. long. The full shape was formed with a tungsten carbide tipped tool and the finish was excellent.

A VISITOR: How long did that tip last between grinds?

MR. DAWSON: Sixteen hours between grinds, but you would be grinding every hour with a high-speed steel tool.

The proceedings closed with a vote of thanks proposed by MR. FINLAY, and carried by acclamation.

COSTING

Paper presented to the Institution, Preston Section, by H. Buxton, F.C.W.A.

The object of this paper is to give a general review of costing and its aims. The importance of continuity and the time element is stressed throughout and spasmodic stocktaking is condemned. Material, labour, overheads, maintenance, and capital investment are some of the main items treated.

In the discussion which follows the paper different views on overtime are expressed. Methods of dealing with "slump" periods are debated, and it is even suggested that production planning with time and motion study should be introduced into office departments.

SINCE I promised to address you on the subject of costing, I have given some thought as to what angle my address should take. Despite the spate of rhetoric and literature which has been published on the subject, I came to the conclusion that it would be more profitable to deal with the subject from a general point of view, rather than from some specific aspect, for two reasons. (1) In my opinion a certain amount of missionary work is still necessary, as the problems of prices and profits remain evergreen, and it is suggested that they are intensely acute, so much so that the mere recording of financial results to conform to the requirements of the statute fail to give the detail necessary for the successful running of either a small or large business. (2) The old days, when this country enjoyed an industrial advantage over practically every country in the world, have gone for ever. Dissemination of knowledge and wider education have brought in their train an extension in the industrial sphere of countries which were formerly devoted to agricultural pursuits, with the result that some markets although open to us are largely being held by local manufacturers. A third point could also be mentioned, and it is one which cannot be ignored by any right-thinking individual. This country, despite the fact that agriculture is still the largest individual trade, is dependent on industry for its prosperity.

Some manufacturers will reply that they have always had a costing system. It is undoubtedly true that costing has been in evidence since business commenced, but primarily as a basis of price fixing, although even then of a primitive character.

As has already been premised, in days gone by there was much less competition, and the evidence now available tends to show

that comparatively few varieties of products were made, and margins of profits generally substantial when measured by present day standards, with the result that there was little incentive to study detail. In addition, rationalization had not been developed to the same extent, and where businesses were small enough to be controlled on a one man basis, the accumulated information and experience could be used with advantage. With the expansion of business and the demands made by customers for a greater variety of products in sizes and qualities, together with the increasing competition, falling margins and even losses became evident, with the result that the problems of cost reduction and economical use of capital were of paramount importance. Knowledge based on fact, not conjecture, was necessary. Knowledge is power, and lack of knowledge invariably results in failure.

Cost accounting should and does tell where and why, whilst financial accounting invariably tells of the results obtained. For a long time cost accounting and financial accounting were almost as the poles apart ; with the adoption of reconcilation statements to marry the two statements of accounts. The tendency at the present time is to make the costing organization the basis on which the financial structure is erected. Many successful industrial companies have so perfected their cost and accountancy organization on this basis that trading results are available for consideration by executives within twenty-four hours of the end of the period, whilst even balance sheets are being produced two to three weeks from the end of the financial year. Without departing from the main discussion, it can be stated also that the adoption of such systems has invariably produced economies within the organisation.

As distinct from the days when a cost clerk's duties consisted of calculating wages, preparing the cost of a particular operation or piece of apparatus, cost accounting as applied on present day principles takes within its purview not only manufacturing costs, but the economical use of material, the economical use of cash and capital resources, and the important question of selling products. It even deals with the efficiency of the office staff. Far too often is the cry made that expenses, factory overheads, or burden, call them what you will, are too high, when it might well be that by increasing overheads, cost reduction could be effected. Effective cost reduction is not obtained simply by reducing the number of labourers or indirect workers, consideration must be given to all aspects of the problem. Design, materials, methods of manufacture must all come within the purview.

Despite the relative measure of prosperity which has been experienced in the last two years, it is very necessary to establish adequate financial control to conserve monetary resources. The setting up of standards and controlling by means of such standards is the

modern tendency. Budgetary control, as it is called by some people, is applicable to small as well as large combines.

The setting up of standards is not confined to standards of quantity of production, but extends to labour, manning, stock investment, work in progress, expenditure on factory overheads, commerical and selling departments, development and capital. Each and every section must contribute its quota if the final results are to be good. Whilst the total results may appear satisfactory on the surface, it is conceivable that they can be improved. It is the function of cost accountancy to locate the weakness, suggest the remedy, and see that whatever improvement is effected is maintained.

Material.

It might well be asked how can standards be set up for materials, but is it not a fact that the preparation of an estimate immediately sets up a standard for materials? It has been proved time and time again that the purchase of the cheapest material is not necessarily the most economical proceedure. Cognisance must also be taken of quality of material to be used, its size and the allowance for scrap or waste. The fact that a few main items of materials are kept in the minds of the leading executives does not in itself constitute efficient control of material. An examination of the material costs of screws, nuts and washers, has been known to result in appreciable savings and increase of earning power.

An increase in the purchasing price of material postulates an excess over standard and a lowering of the anticipated profit or, as sometimes happens, an increase in the loss, such excess can be included under the heading of inefficiency of purchasing. It also does not necessarily follow that, because total costs of material conform to the standard previously determined, economical use of material has been achieved. The fortunate purchase of a higher quality material might well be the reason why the total actual costs and standard costs agree. Consistent prosperity demands that efficiency is maintained all the time, whereas cases have been known where the prosperity is more apparent than real, due to a somewhat fortunate purchase of material. In other words "a lucky speculation."

In the majority of other industries, except the coal industry, material is the highest constituent element of cost and, if only for this reason, it demands much more consideration than is given to it in some cases. Having determined the standard in respect of quality, quantity and size, it is essential that the necessary organisation be set up to ensure that variations from the standard are recorded. It is frequently the practice that, in order to meet the needs of a particular case other material is used, either of a better

quality at a higher price, or a greater quantity, arising chiefly from increased size and resulting in excessive wastage.

The conservation of cash resources from the efficient use of capital also demands that serious consideration is given to delivery of materials required for manufacturing. A healthy rate of turnover must be obtained, not only on stocks but on work in progress. Materials delivered one month before they are required may mean that the anticipated profit has been absorbed by loss of interest. Cost accountancy demands complete materials control, and when arranging the production programme, this factor is more than worthy of consideration. Stock materials are a potential source of loss. As a general rule, some form of stock recording is undertaken, but cost accounting working to standards means something more than merely details of orders placed, receipts, issues and stock balances.

In these days of changing fashions, the risk of losses arising from obsolescence is a real one. It must be borne in mind that, if such losses do occur, there is at least a reduction of profit margin. A more scientific use of stock records is required, with maximum and minimum stock levels and ordering quantities established, after taking into account such questions as rate of turnover, replacement period and economical manufacturing quantities. It is not sufficient to be left to the ideas of one individual. These bases must also be under systematic review to keep pace with the changing conditions, as only by such methods is an adequate rate of turnover of stock to be maintained to conserve capital and diminish, if not entirely avoid, the losses which arise from obsolescence.

In determining the organisation and control of stores and material, consideration must be given to the establishment of perpetual inventories. The days are gone when it is necessary to close down the factory in order to take stock to conform to the requirements of the auditors, or, in order to determine in the intervening period, what the trading results have been. Is it realised what losses are are suffered by the adoption of such procedure—loss of potential output and the greater incidence of the burden of factory overheads? The elimination of these intermediate stock-takings and a reduction of the time required to take the annual stock will be ample repayment for the adoption of a more scientific system of stock records with perpetual inventories. No problem is too great in this direction, and it is my personal experience that considerable sums have been saved by well thought out systems.

Labour.

The control of labour costs is dependent upon the type of product and methods of manufacture. It will, no doubt, be said that an analysis of the payroll is undertaken by most organisations under

broad headings, and for the purpose of preparing information for the financial accounts. An up-to-date system of standards as the controlling medium will reveal much more.

In the case of what may be termed " process shops," where the labour functions on a team basis, an effective system of standards will indicate additions to the team, whilst in the case of work shops where the employees work as individuals, it will reveal the work done at day rates in lieu of piece-work. Further analysis will reveal the cost of that easy but undesirable solution of difficulties—overtime or week-end work. The extra cost of this time, namely time and a quarter, time and a half, or double time, is often overlooked or considered a necessary evil. A detailed study of the causes leading up to overtime will often disclose that it could be avoided by an improvement in the organisation relating to material, additional equipment, or even repairs to existing equipment. Customers rarely pay for overtime costs, and more often than not, it becomes a very definite overhead charge. Overtime and weekend working should be treated like the plague and receive the attention which the plague would demand. It will never be eliminated, but it can be kept within limits.

Labour turnover is also not an item to be ignored. The fact that an operative may be earning piece-work does not necessarily mean efficiency. If piece-work earnings are low, additional costs have been incurred in the way of additional factory expenses. Haphazard selection of employees can be an expensive procedure. Variations from standard will also be revealed where operations are performed on one machine, which could be undertaken more efficiently on another.

Overhead Expenses.

Overhead expenses can be broadly divided under the following headings :—

(1) Services—fuel, electricity, steam, compressed air, gas producing, water, transport.
(2) Departmental charges—or those which can be stated to be under the direct control of the department.
(3) Maintenance charges—expenses on labour and material sustained in the repair and upkeep of the buildings, plant and machinery.
(4) General service charges—shipping, carriage, stenographic and mailing, telephone, works accountancy, etc.
(5) Fixed charges—rents, rates, taxes, fire insurance.
(6) Commercial and administration expenses—the expenses incurred by sales and commercial departments, branch offices and general administration.

Standards of overhead expenses can be set up for varying volumes of output. The initial work is somewhat lengthy, but after establishing these standards, the work involved in maintaining them up to date is relatively small and well worth the expenditure. As in all other items of cost, it is of no value simply stating that overheads are too high, careful consideration must be given to each and every item—" Fix the standard and measure the variation." After all is said and done, the most important feature is to indicate where losses are being incurred, and why.

To refer to a few of the items :—

1. *Services.*

Electricity. In process shops the consumption in terms of units can definitely be measured in relation to output. Any excess is a wastage or loss, which is capable of elimination. A more difficult problem arises in machine shops with a variety of machines and products. Nevertheless the relation of consumption to output can be measured. A study of electricity costs in conjunction with the load chart is also some times illuminating, as it shows the length of time taken to reach full load, the time at which full load operates, and the time the load begins to drop. If the acceleration can be improved, it can be taken for granted that there has been some increased output obtained for it. Likewise if the commencement of falling off can be delayed and the actual fall off made more acute a further improvement should accrue.

Steam. Steam costs are a fruitful source of investigation, particularly when setting up standards. The theoretical calculation of consumption by using units and comparison with that generated, invariably discloses a much higher loss than anticipated.

Fuel consumption in relation to pounds of steam raised is also well worthy of consideration, and this may ultimately lead, where alternative supplies of fuel are available, to a consideration of the relative merits of hard coal, nuts and pulverised fuel.

Compressed air costs. Just as much criticism may be directed against wastage in the cost of compressed air. If this is supplied at too low a pressure loss of output will ensue. It is, therefore, essential not only to have an eye to the actual expenditure, but the value of the supply.

2. *Departmental Charges.*

Under the heading of departmental charges would be included such items as sundry materials—electric lamps, oils, greases, cleaning cloths, stationery, sundry labour—charge hands, departmental storekeeping, training of new employees and defective workmanship. It is proposed to review defectives on a wider scale at a later stage. The setting up of standards for such service charges and

departmental charges, in conjunction with the head of the department and the subsequent issue of the results with a brief statement of whether gains or losses have been made, together with the total gain or loss, creates a competitive spirit. Moreover where excesses do occur, the cause is quickly detected and prompt action can be taken to prevent repetition.

3. *Maintenance Charges.*

It is suggested that if ever there was a group of expenses in any manufacturing organisation which deserved more time and thought than have been given to them in the past, it is surely this group of maintenance charges. In times of prosperity it is stated that systematic overhaul cannot be tolerated owing to the interference with production and lowering of output, and it is only the repairs following breakdowns, which are undertaken. Conversely, in times of depression, or to be more in keeping with the times, recession in trade, repairs cannot be done because there is no money available. There is a further danger that, in time of prosperity, the cost of the additional wear and tear is entirely overlooked. Therefore, to establish standards of expenditure, systematic study must be made.

Briefly, a machine or piece of equipment can be divided into two sections : (1) Stationary parts ; (2) moving parts. Stationary parts require little or no maintenance and remain good for the complete life of the machine, and in consequence, expenditure is on a comparatively small scale.

Moving parts are subject to wear and tear and maintenance can be very costly. A study of this question cannot be confined to the older machines, new machines must also receive consideration. The suggestion, therefore, is that in determining the costs of production, a detailed study of the plant is necessary, and an attempt must be made to predetermine maintenance costs on a life basis. A whole host of arguments will be brought forward about the impossibility of determining how long a spindle or a bearing will last, but quiet thought and study will produce more satisfactory results than if nothing is done, and as time develops and the opportunity is taken of adjusting the forecast, real benefit will accrue. Is it not far better to have made some provision for a future liability than nothing at all ? How often after installing a new machine has it been felt that " everything in the garden is lovely," then at some later date to receive a rude awakening by a heavy bill for repairs, which disturbs the balance of profits or a particular period. The estimated costs of maintenance in this scheme should be taken to a maintenance reserve fund and the actual expenditure debited against it. When trade is not so good, the opportunity could be taken of maintaining plant and equipment in an efficient state,

without impairing the financial results. Thus the firm would be prepared to deal with the increased volume of trade when it came along.

Take another aspect of the same question. Systematic study reveals the frequency of breakdowns and may, in some cases, lead to the question whether, e.g. an improvement in the quality of material would give longer life at a lower cost. Another advantage is that any time a valuation of the plant is required, access to such information would be invaluable and would often enable this to be done by the existing staff, without incurring the expense of outside valuers.

4. *General Service Charges.*

From time to time various attitudes are to be observed regarding this factor of expenditure. On the one hand there are the expenses which have to be borne and nothing further can be done, whilst on the other a resort is made to reducing wages, or employing a lower grade of labour, without consideration being given to whether an improvement in the organisation, methods and even a higher class of labour, would not be more remunerative. A lot of work in an office can be organised on a production basis and even payment by results established. The day has gone by when production problems stopped at the office door. It is of little use preaching efficiency if efficiency is not practised. Time and motion study even play their part.

Defectives.

A discussion on costing and factory expenses would not be complete without some reference to defectives. Defectives are a waste, wastage costs money, and no matter how small, reduces profits. It goes without saying that the majority only engage in business to produce profits, and at no time should any individual be satisfied that the best result has been achieved. Defectives must be recorded, but that is not enough for the most important point is to ascertain the cause of defectiveness. When the cause is known the remedy can invariably be applied. The classification of defectives under the heading of workmanship, design and material is the first step, and consideration should be given to the further classification under these headings, with the object of determining the factors creating the defect. It is imperative to note what effect defects have on the costs of products, but in order to do this efficient material control is essential. Slipshod methods debar the correct ascertainment of the cause of defects. There is a further point that, unless defects are recorded, cost comparisons between one accounting period and another are vitiated. In the setting up of standards

of overhead expenses, the item of defectives should be regarded as an entire loss, and considered as such. It may be necessary, when considering whether progress is being made in the direction of reducing these losses, to compare with past performance. It is, absolutely essential when reviewing costs of production, to take cognizance of the costs of defectives, otherwise prices may be fixed on too low a basis.

Application of Overhead Expenses.

In the application of factory overhead expenses to the product, it may be stated that they are largely related to the factor of time or unit of output, and generally, the most equitable means of distribution is on either or both of these bases. However, in determining the costs of production, it is possible in some cases to apply the actual factory expenses, whilst in others it is necessary to use a predetermined scale.

The application of actual factory expenses is more generally applicable to process manufacture, e.g. steel works, chemical plants, coke-oven and by-product plants. In order, however, that cost comparisons between one accounting period and another may not be vitiated, it is usual when the production level is below normal, to assess the effect of the lower capacity and charge the value up to a special account. Under this scheme, fixed charges, rent, rates, taxes, insurance, salaries and some service charges would be included, and the proportion that the lower capacity represents to the normal level would be charged to the special account, e.g. assuming that 100 is the normal production level and 80 was the level during a particular accounting period, 20% would be debited to this account. In effect, this means that a loss has been incurred owing to the sales having failed to achieve the normal production requirements.

The application of expenses on a predetermined basis is generally used in those cases where the measurement of the volume of production is of a more difficult character. This method is applicable in machine shops, or other departments where the product is of a diverse nature and both hand and machine methods of production are employed. Two methods are available : (1) The application of a machine rate or a hand rate. (2) The application of a fixed percentage on wages basis.

The application by the former method is desirable in cases where the product or the labour is of a variable nature. The application by a fixed percentage on wages basis is a simple and ready means where the product is confined to a few types and sizes, or where the labour is limited to a few classes.

Occasionally, the application of overhead expenses is found to be on both labour and material, but by reason of the tendency for

material to fluctuate widely, with considerable discrepancies in the price of different classes of material, this method is not recommended.

We have not yet reached that stage where the volume of production remains constant. Peaks and valleys recur at frequent intervals, and in times of depression the question which looms uppermost in the minds of executives is, at what prices can we afford to take business, in order to keep production on a more even keel? Although our sales friends tell us that demand fixes selling prices, there can be no doubt that over a long period of time costs fix selling prices, otherwise there would be no logic in production, as profits would be non-existent. It is therefore essential to determine how the costs which are to be the basis of selling prices are to be computed. Reference has previously been made to this, and it is considered to be imperative to know what the effect of volume has on the costs of production. It is quite obvious that, if costs for the purpose of fixing selling prices were based on a low level of production, they would be so high as to reduce the chances of obtaining business to well nigh vanishing point. To be logical, therefore, why not design the cost system so that it will serve all purposes, including the measurement of efficiency and the basis for fixing selling prices.

Apart from the losses which are suffered as a result of the low level of production due to the smaller sales volume, losses occur from time to time within the factory due to waiting time, including waiting for material, tools, cranes, failure of the power supply, breakdowns of the plant or equipment, changing over from one size of product to another, or setting up. The costs of these stoppages are a distinct charge to the cost of production and are a part of the overheads, whilst their measurement is a necessary feature of any system of cost accounting. The fact that they are recorded will enable a study to be made of the cost and determine any weakness in either the production programme, the efficiency of the power supply, or the efficiency of the maintenance services. Whilst it may be necessary from time to time, to make changes in the production programme to deal with a temporary difficulty or to meet the specific requirements of customers, the cost of doing this must be available.

Turning now from the purely factory side of production costs to commercial selling and administration expenses, it is again essential that something more than a cursory review is taken. The fact that a certain article has been sold, in a large measure postulates that a certain allowance or standard of expenditure has been legislated for, and it is the function of cost accounting to watch that the actual expenditure conforms to it. The classification of expenditure is the first essential to be undertaken by the measurement of the incidence of the expenses in the form of cost per unit,

per ton, or per pound, in total, by districts or areas, or against individual salesmen. Standards of expenditure combined with standards of the sales volume in total and by districts or areas, are something more than mere platitudes ; they can be exceedingly illuminating.

The application of commercial selling and administration expenses to the product presents a much more difficult problem than those of factory expenses. A good deal of thought has been and is being given to this subject at present, and it is exceedingly difficult, if not well nigh impossible, to give more than a general line of thought on this subject.

The loading on to the product of such items as advertising and publicity present one difficulty, the small and large order another, whilst the type of product with a wide range of values cannot be dismissed, nor is it possible to lay down specific rules for a particular industry ; each organisation must be considered on its own. A commencement, however, in the direction of : (1) Classification of expenses ; and (2) elimination of the known factors, will materially assist in arriving at a more correct solution than by simply assessing on a general all-round basis.

Capital Investment.

The maintenance of an adequate rate of turnover on the capital investment for the business in stocks and work-in-progress is of sufficient importance to warrant more than a passing thought. A review of the allocation of capital over a wide variety of trades discloses that stocks and work-in-progress invariably represent more than 50%, and if only for this reason it is well worth some time and thought.

Reference has previously been made to the subject of maintaining an adequate rate of turnover, and scientific planning of the production programme is essential to the successful solution of this problem. It is not enough simply to order material, some attempt must be made to regulate its incoming and afterwards, to preserve the balance between the various units comprising the finished product. The receipt of material in the factory often means that labour is spent upon it and further capital is tied up. If, therefore, the labour is not applied in organised sections, it may be that components or sub-assemblies may be lying on the floor of the shops or in stores a longer time than is necessary waiting for the other components or units to be produced. The manufacture of the product is one thing, and to do so having due regard to the time aspect is another.

Within a comparatively short space of time it has been my experience that : (1) An increase in the capital of an organisation, which had progressed so far as to discuss terms with the underwriters, when the issue was vetoed on the grounds that a more intensive

scheme of planning and production, combined with improved stores and material control, would release a large amount of money, and subsequently give a greater rate of turnover. (2) Production was sold at less than the normal price levels to improve the cash position. (3) It has been possible to invest surplus cash in order to increase earnings.

It is quite conceivable that in the minds of some of you the thought has been passing that a costing system instead of reducing the cost of production, will increase it and place a further burden on the organisation. It can, however, be truly stated that the installation of a modern costing system, combined with planning and production of the routine, time and motion study, and even payment by results, has not only assisted managements to deal with the many problems with which they are confronted, but has also resulted in economies in the office side of the organisations with the final balance on the credit side of the ledger.

In conclusion, it is hoped that this review of what should be the aims of costing, rather than the outlining of some specific system, has met with your desires. Information or statistics relating to any activity do not of themselves provide executives with the solution to the problems with which they are confronted day by day. Facts are needed, but these facts must be in the form of news and not history. Provided that these are obtained, diagnosis and the remedy can invariably be obtained. This, combined with the undoubted skill of the British workman, will materially assist to retain our place in the markets of the world, and above all, to enable us to enjoy, perhaps even improve upon that standard of life which we have experienced up to the present.

Discussion.

MR. KEMP : Mr. Buxton made a statement that he could produce a balance sheet in two or three weeks. I do not know just how this is done. In most works the production of a balance sheet necessitates a certain amount of extra effort on the part of the office staff, and if you have a surplus staff to work the balance sheet out and produce it in two to three weeks, you will have there, I think, a case for cutting down office staff. If you are going to introduce special office staff for this work and special staff for taking stock, all well and good. Again, on the question of taking stock, does Mr. Buxton intend that stock shall be taken from actual materials or from stock record cards ? Another point. Take a shop working on a machine basis where you have a machine that is charging at the rate of six, seven, or eight shillings an hour, for that machine (and there are machines to-day that probably take 20, 30, or 40 horsepower to drive) there may be times when the actual machining of the job will occupy only half of the time which will be taken in setting up. Would Mr. Buxton suggest a special rating for that machine for setting up, seeing that the power is not being used ?

MR. BUXTON : In regard to the balance sheet and stocktaking point, I will go so far as to say that balance sheets in a good many offices are not produced once every twelve months, but their organisation is such that it automatically gives a balance sheet every four weeks, so that there is only the final clearing up at the end of the year to do. Furthermore, the actual results then available tell you not only what gross profit you have made, but provide an analysis of production from beginning to end.

On the question of additional staff none is required. The work can be done if as much thought is applied in the office as is applied in the shops. Time and motion study, a production plan, and it automatically goes forward, so that you can definitely get even trading results within twenty-four hours and a balance sheet within two to three weeks comparatively simply and without overtime.

On the question of stock-taking, I suggest that perpetual inventories, where established, and automatic checks set up at frequent intervals, will give you far more accurate results than any stock taking which is done at year end, half-year end, at the end of the month, or any period you like to take. You cannot afford to shut the factory down to take stock, and we have got to the stage now, where auditors and accountants coming along to vouch for your records will be prepared to accept perpetual inventories.

On the machine which takes a tremendous amount of time for setting up, it would appear that you have got to make two rates, one for setting up and the other for the actual working time. You must bear in mind that the only factor which is not being incurred is the consumption of electrical energy. The consumption of electrical energy might be a comparatively small amount compared with the other overhead expenses, such as supervision, rents, rates, taxes and the lack of earning power whilst the machine is standing idle. This question would have to be considered on its merits.

MR. WESTALL : I would like to know how you arrive at overhead charges for a machine shop on general engineering work, as production work is becoming more involved. Mechanically the production costs are reduced but the overhead expenses are increased. I would like to know how you arrive at the costs of a department of that type. What method would you use for putting an extra charge on your production costs to cover these maintenance expenses ?

MR. BUXTON : I suggested that we should deal with the collection of expenses and the assessment of the overhead expenses, on a life basis in the first instance—determine beforehand what the actual expenses will be. The collection of the cost of repairs can be done fairly simply—by classification of departments—call them No. 1, 2, 3, and so on. Give the machine itself a number, say 1/100, or get out a system 1/1 or 100/100, to suit your case and that will remain throughout its life, so that you get them collected in that manner and you automatically get the cost of your repairs in the same way.

MR. WESTALL : Do you mean for each particular machine ?

MR. BUXTON : Yes.

MR. WARDLAW : Mr. Buxton said something about facts presented to the management being news, not history. I think he touched there on a very vital subject in costing. In my experience, to give a works management news would often necessitate a costing staff of double size. What management would dream of double staff in these cases ? Of course, they consider the installation and expense of mechanical means of accounting, but there again, they may turn them down. I would say that to give news and not history is often a more expensive and more difficult task than Mr. Buxton would make us believe.

The second point is that Mr. Buxton, though I may not have heard him quite correctly, makes an allusion to reconciling costs with the financial records. From time to time the management receives streams of statistics and figures ; they look very nice, but I think you will find that reconciling costs with the financial results is a very difficult job unless you have an army corps of clerks.

A third point—Mr. Buxton mentioned the fixing of efficiency standards in the office. That can be done if you have an office staff,

say, the size of Imperial Chemical Industries or the Bank of England. The small general utility staff in a normal engineering company is different, and the expense of an office manager fixing efficiency standards would offset any gain he may get from it. I admit, of course, that each member of the office staff should be efficient in his particular sphere of routine or duty, but I got the impression that Mr. Buxton was looking upon the office staff in the same way as shop operators have a rate fixer, and I am not looking forward to the day at all when the office staff have as office manager a man with rate-fixing ideas.

MR. BUXTON: The application of "news and not history" methods is not the prerogative of machinery methods. I suggested in my paper that time and motion study, planning and routine, may be the solution. I can quite well believe that mechanical means are necessary in some instances—hand methods in other cases are the solution—every case should be considered on its merits. The important point is this, that news and not history will be more readily obtained if you apply the same principles in the office as you do in the works.

In regard to reconciliation of financial results and cost accounts, I said early in the paper that for a long time cost accounting and financial accounting were almost as the poles apart, with the adoption of reconciliation statements to marry the two statements of account. The tendency at the present time is to make the costing organization the basis on which the financial structure is erected. For the last twenty years I have been adopting that basis and it has not been necessary to reconcile either cost or financial accounts. Cost and financial accounts, as far as I am concerned, do agree.

On the question of a rate-fixing department being introduced into the office, well, I feel that if you are going to preach efficiency, you must practice it. It is not a case of "Don't do as I do, but do as I say." It is "Do unto yourself as you do unto others." You can definitely practice planning and production rate-fixing methods, and time and motion study has not been considered half as much as it ought to be, even in the office. Furthermore, if you do this, the people in the office will do more work with less effort than they have done up to the present.

A VISITOR: Has our lecturer any recommendations to make concerning the application of overheads arising during period of slackness and suspensions? Parts of the offices and shops are closed down perhaps, and other parts of the shops are quite busy. No doubt he has come across such cases and has some recommendations to make in this direction.

MR. BUXTON: I tried to visualize that point in writing this paper. In setting up a certain size of factory you must have determined what the normal level of production is likely to be, and at a

later stage you might have brought in another type of product; later on still you may have reached a stage where the two are out of balance—say, for example, one is working at 50% and the other working at something more than normal load—perhaps 110%. Your question referred to the rating of the one working at 50%. In the first case, in fixing these standards of expenditure you must have had some record of the normal level of production. If you have fixed them, and you are working below the level the fixed charges are going on, although that product is working below 50% and must be taken from your cost accounts—it is almost an arithmetical sum to do so. On that basis compare the efficiency of the shop under abnormal level, with what it should be under normal level and you can then discuss the question of costing comparison, and as a result of that obtain your overhead expenses; then work this out with your works manager or departmental head. If your costs are high, that is, working up to about 50%, then the answer in itself is the low level of production, but you cannot regulate that; it is easy to regulate the cost of production according to load in the factory, setting the standard at a lower level. On the subject of fixing selling prices, the only logical means is to assess what the normal load is, see what the expenses are with normal load and fix the price on that. Coming back to my point in the paper, you have a common denominator in the establishment of your costs system, and it must be the same measure of your level of efficiency as is fixing the selling price.

MR. O. RENDELL: Our lecturer may be able to help me on the question of work in progress. In regard to getting out your stocks, the money owing to you and the money you owe, this is possibly quite easy to do in twenty-four hours, but work in progress finishes at 5 o'clock every night, and I cannot see any clerk getting out an accurate balance sheet, giving work in progress, by 5 o'clock the following night.

There is another point you raise, that is, you state in your stocks, minimum stock and maximum stock; here also you may be able to help me. We deal in fairly large castings, which when they are put into the stores are not moved unless they are required for work in progress. In some cases we must have three of these castings in stock always, and I now find that I have in stores three castings which have been there twenty-five years!

In my early days in business the proprietor was showing me round his works. "Well, young man, what would you like to see next?" I said, "I think I'd like to see your costing department." "Costing department?" he replied, "I am not going to pay anybody £500 a year to tell me I have lost £1,000, when I might have only lost £500 if I hadn't had him."

MR. BUXTON : Thank you very much, Mr. Rendell, for the last anecdote. I can only again repeat that practical experience tells me that whether it is a £10,000,000 combine, or a £10,000 company, or even a £1,000 company, it is possible to produce a balance sheet much earlier than it is being done to-day, if there is any organised method in existence. There are quite a number of diverse companies who are producing their trading results in twenty-four hours and balance sheets in two to three weeks. You can have your period ending at 12 noon on Saturday and before 5 o'clock on Monday night you can have your results available. If your period ends on the 31st of the month and this coincides with 12 noon on Saturday, I would even go so far as to say that you could still have your results available by 5 o'clock on Monday evening, and that twenty-four hours is sufficient.

If you organise your costing system properly, your work in progress is an integral part of your finance account. It does not need any valuation or stocktaking for the purpose of your immediate financial results or even your balance sheet. The day will come when we shall have sufficiently convinced accountants and auditors that the taking of stock of work in progress is simply a waste of time—that day has not come yet, but it will come.

On the question of minimum and maximum stock levels, I suggested that these should not depend on the ideas of one individual, but the ideas of, shall we say, the chief storekeeper, the works manager (who is going to use the stock) and also the selling department, and it is the cost accountant's job to see if, for instance, three castings are in stock over a certain period of time, that the fact is drawn to the attention of the management. "You have three castings in stock which cost you so much money ; you have not sold them yet. Are you going to make any special efforts to sell them, or recognise them as a loss which will go against your trading profits ? " That is the only way you can deal with that job.

MR. R. D. G. RYDER (*Section President, who presided*) : Mr. Buxton mentioned that material is the most costly item to be considered. That might apply in some trades, but labour in a large number is by far the most expensive, and the work of a cost accountant's staff is very much increased if they are dealing with labour.

While we are on the subject of material, he says that you should not get your material in too early, because it costs you money while it is waiting to be used ; on the other hand you should not get it in too late—it costs money to keep men and machines waiting. Well, we have not yet found anybody who, when they were asked to send in a gross of screws on January 1 and given six months to do it in, did not—ten to one—send them in on November 1, because they wanted the money, or in February because they had forgotten all about them ! It is very hard, especially in times like these, to get

material in to time ; you get a promise of delivery and it is not kept. Whether you order too soon or not early enough, somebody is going to send the stuff in because he wants the money.

Mr. Buxton mentions the life of a machine. I am interested in machine tools and I should like to know what is the life of a machine tool. At what are you to estimate this ? I remember reading a lecture by a member of a big motor-car firm, who was giving a talk to one of the sections of the production engineers, and he raised a storm by taking the life of a machine tool as fifty years. Up jumped another gentleman who was in an equally big motor-car firm, and he was talking about five years. Now, there is a tremendous difference between these two ; which is the right basis to work upon ? Are we to fix a minimum period in which a machine should pay for itself, or are we to take the actual working life of the machine and so enable ourselves to fix a lower depreciation rate ?

A point was mentioned about repairs and maintenance. If you keep a record of each machine in your shop, and what it has cost each year in repairs, when you look through the book at the end of a period you may find a machine of £100 capital value has cost £200 in repairs, and it makes you think it is time you scrapped it.

Mr. Buxton feels very strongly on the point of overtime. It does cost a little more in wages, but not a lot more. It may cost more in loss of efficiency than we can estimate. We can estimate the loss of efficiency in a group of girls making a wireless set, say they have a definite time to work to, but in a general engineering shop I do not think that loss of efficiency amounts to a great deal. Besides, some of the men like overtime ; if they do not get it there is jealousy : " He is on overtime—I am not. Why ? " And yet another group would not have overtime at any price. But I do not think overtime is quite such a deadly sin as Mr. Buxton has made it appear in his lecture. I should like his further views on these points.

MR. BUXTON : Mr. Ryder on his first point wants me to say what is the happy medium. There is just as much danger in trying to get too close to the point as there is in doing nothing at all ; if we get too close to the point, there are losses due to the plant being idle, which will probably be more expensive than having to borrow money from the bank to finance the business. I still contend, however, that with proper production planning, some regard must be given to the financial aspect, and by doing so you achieve better results than if nothing was done at all.

I tried quite early in my business career, when dealing, for instance, with a large and costly piece of machinery, to say : " This is a big part ; we will get this in first and then we can be doing something." But it was an item which cost a fair amount of money, and upon consideration of the problem, instead of being first it was

about tenth or eleventh in the scale, and it helped to improve our later turnover and we had better earnings from it.

Mr. Ryder refers to firms sending in goods before the due delivery date. The remedy is simple ; don't pay for them before the date due.

In regard to the life of a machine, two points really arise from that question. There is the cost of repairs while the machine is operating or during its working life, and the second point, of depreciation. I consider it essential that the cost of machinery repairs should be assessed on a life basis, and by " life basis " I mean its working time. If, for example, you say that on approximation a part will wear out after 1,000 hours work, then that 1,000 hours is spread out over one, two or three shifts, and you must calculate your costs for repairs on that basis. You should then have a reserve fund at the end to meet the bill. If you do nothing at all, and you work on the three-hour shift system, your repair will become necessary much earlier than if the machine only worked one shift per day, so it is definitely safer to assess it on a life basis.

A second point on machine life—one man said five and another said fifty years. I have found in practice that the allowance which is actually given by the Inland Revenue, and which varies from 2% up to 20% on the cost of machinery and equipment, is a fair basis on which you can estimate depreciation.

The case of the machine in stock which originally cost £100, and on which £200 was expended in twelve months, would obviously be brought to light and some thought given to it.

Regarding overtime, I am not going to be quite so dogmatic as to say no overtime is necessary ; it may be necessary. What I suggest is, do not ignore the fact that there are other ways of getting over the difficulty than by saying : " We will work overtime to-night, or to-morrow, and so on." It has been proved that the time-and-a-half or time-and-a-quarter you pay for overtime will give you some tangible asset if you buy some modern machinery ; if you have got to pay overtime continuously, then at the expiration of that time you have nothing to show, and it is definitely a consideration as to what steps can be taken to eliminate overtime. The price you have got to pay for the alternative and the price of overtime is definitely a question of economics.

Mr. Rendell : I should like to say that you have got to allow a lot more depreciation than the Inland Revenue will allow you on your accountant's balance sheet, or you will be in a very poor way in ten years' time. You must allow a lot more than that. I think that I am right in saying Dr. Schlesinger states that the life of a machine tool is from four to six months if run continously twenty-four hours per day.

Mr. Buxton : I probably did not make myself sufficiently clear.

The Inland Revenue will allow you more than that, say, 7½% up to 20% on furnaces which are working round the clock.

MR. RENDELL: There is one very serious point in regard to overtime, if you have got very heavy machinery. If you have to buy plant, one machine tool may cost as much as £10,000 to £15,000 and unless you work overtime and night shifts you cannot make that machine tool pay.

MR. BUXTON: In that case, buy a machine tool for continuous work and recognise it as such, but if you have to start on Monday morning at 6 o'clock until noon on Saturday, and then continue on through Saturday afternoon and Sunday, you must consider whether additional facility is not required.

MR. R. G. RYDER: I understand that the costing system is a system of measurement. If I understood Mr. Buxton aright, he uses it as a control system. I suggest that that will lead to false costs. You will get people booking things to accounts that will not stand it. I would like to have Mr. Buxton's views on this point.

MR. BUXTON: The system is both control and measurement. It serves the dual purpose by the one operation. The control system is by the setting up of a standard and the measurement of performance against it. If you set up a standard and put your actual results alongside, that gives you the measurement. The actual expenses which you get are carried forward into cost accounts and finance accounts in the ordinary way, but if you set up standards you can see where the results have fallen short of your preconceived ideas, and your investigations will show why.

It is by the process of elimination that you get along. You will find that to wipe out inefficiencies you have to increase some standards and lower others, until you reach a point approaching the ideal and then you get something nearer the actual truth. Furthermore, the fixing of standards is not the prerogative of the cost accountant, but should take in officials such as the works manager, foremen, etc. By doing so you get a much better feeling existing between the costs department and the works people. The cost accountant's job should be to get the goodwill of the works side and get them to realise that it is through their help and constructive criticism that the efficiency of the works as a whole is maintained.